Anuj Apte

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Summary

Senior Research Associate at JPMorgan Chase working on **deep learning** and **quantum computing**. Background as a theoretical physicist with expertise in mathematics, numerical simulation, and high-performance computing.

Skills

DL: PyTorch, JAX/Flax **Systems**: Git, Slurm **Languages**: Python, C++

Education

2020 – 2025 **Ph.D. in Physics**, University of Chicago, Chicago, IL GPA: 4.0/4.0
Dissertation: Deep Learning and Non-Invertible Symmetries in Gauge Theories
Selected Graduate Coursework:
Machine Learning: Deep Learning Systems; Foundations of Machine Learning; Machine Learning for Molecular Modeling
Quantum Computing: Implementation of Quantum Information Processors; Quantum Complexity Theory; Quantum Computing
Mathematics: Algebraic Topology; Differential Geometry

2016 – 2020 **B.S. in Physics and Philosophy**, MIT, Cambridge, MA GPA: 4.9/5.0
Minors in **Mathematics** and **Music**

Experience

Senior Research Associate — JPMorgan Chase Jul 2025 – Present (New York, NY)

- Researching spectral matrix-aware optimizers such as Muon and Shampoo to understand their token efficiency and ways of reducing their computational overhead.
- Extended quantum approximate optimization to integer problems, and derived a new framework to analyze the quality of solutions. Proved that for it can outperform semi-definite programming (SDP) for the Max-K-Cut problem [1].
- Designed scalable warm-start method for Quantum approximate optimization algorithm and benchmarked it's performance on trapped-ion hardware. We demonstrated that it can match the classical state of the art for the Max-Cut problem on regular graphs.
- Rigorously proved that there are continuous optimization problems for which Quantum adiabatic algorithm converges exponentially faster than classical gradient based methods (SGD) [2].

Graduate Research Fellow — University of Chicago Jul 2020 – Jun 2025

- Built equivariant CNNs in JAX/Flax for learning lattice quantum systems, achieving state-of-the-art ground state predictions. We employed a layer-sequential unit-variance initialization to prevent exploding and vanishing gradients in deep multiplicative layers, and trained with natural-gradient via the quantum geometric tensor to improve accuracy [3].
- Proved that quantum systems with certain topological symmetries cannot form simple stable phases, establishing that they must form highly correlated states [4].

Internships — MIT, NASA, Xanadu, IBM Research, JPMorgan 2020–2024

- **JPMorgan:** Researched quantum optimization via Chebyshev interpolation, reducing circuit evaluations. Built parallel GPU simulation pipelines on AWS EC2, with Slurm-style scheduling and resource optimization for large-scale experiments [5].

- **Xanadu:** Designed algorithms for Gaussian photonic circuit simulation with quadratic speedup over previous state of the art. Our algorithm allows one to compute derivatives of the output state with respect to parameters of the circuit, similar to backpropagation in neural networks. This enables a **100**× runtime improvement for GKP state preparation [6].

- **NASA QuAIL:** Developed theoretical models to explain surprising behavior of QAOA circuits at large depth, providing insights into convergence of the algorithm [7].

- **MIT Kavli Astrophysics:** Computed inclined inspiral trajectories into Kerr black holes; accelerated waveform simulations for extreme mass-ratio binaries with C++ code [8].

Honors & Awards

2022 **Nambu Fellowship** — awarded to the top-rated Ph.D. applicant at the University of Chicago
2020 Inducted into **Phi Beta Kappa**, Massachusetts Institute of Technology
2015 **Gold Medal**, Asian Physics Olympiad, Hangzhou, China
2015 **Silver Medal**, International Physics Olympiad, Mumbai, India
2011 **National Talent Search Examination (NTSE)** Scholar, Government of India

Selected Publications

[1] **Anuj Apte**, Sami Boulebnane, Yuwei Jin, Sivaprasad Omanakuttan, Michael A. Perlin, Ruslan Shaydulin. *Quantum Approximate Optimization of Integer Graph Problems and Surpassing Semidefinite Programming for Max-k-Cut*. 2026. arXiv: 2602.05956 [quant-ph]. URL: https://arxiv.org/abs/2602.05956.

[2] Dylan Herman, Guneykan Ozgul, **Anuj Apte**, Junhyung Lyle Kim, Anupam Prakash, Jiayu Shen, Shouvanik Chakrabarti. "Mechanisms for Quantum Advantage in Global Optimization of Nonconvex Functions". In: *QIP 2026* (2025). URL: https://arxiv.org/abs/2510.03385.

[3] **Anuj Apte**, Clay Córdova, Tzu-Chen Huang, Anthony Ashmore. "Deep learning lattice gauge theories". In: *Physical Review B* 110.16 (2024), p. 165133. DOI: 10.1103/PhysRevB.110.165133.

[4] **Anuj Apte**, Clay Córdova, Ho Tat Lam. "Obstructions to gapped phases from noninvertible symmetries". In: *Physical Review B* 108.4 (2023), p. 045134. DOI: 10.1103/PhysRevB.108.045134.

[5] **Anuj Apte**, Shree Hari Sureshbabu, Ruslan Shaydulin, Sami Boulebnane, Zichang He, Dylan Herman, James Sud, Marco Pistoia. "Iterative Interpolation Schedules for Quantum Approximate Optimization Algorithm". In: *arXiv preprint arXiv:2504.01694* (2025). URL: https://arxiv.org/abs/2504.01694.

[6] Robbe De Prins, Yuan Yao, **Anuj Apte**, Filippo M. Miatto. "A Quadratic Speedup in the Optimization of Noisy Quantum Optical Circuits". In: *Quantum* 7 (2023), p. 1097. DOI: 10.22331/q-2023-10-23-1097.

[7] Vladimir Kremenetski, **Anuj Apte**, Tad Hogg, Stuart Hadfield, Norm M Tubman. "Quantum alternating operator ansatz (QAOA) beyond low depth with gradually changing unitaries". In: *arXiv preprint arXiv:2305.04455* (2023). URL: https://arxiv.org/abs/2305.04455.

[8] Scott A Hughes, **Anuj Apte**, Gaurav Khanna, Halston Lim. "Learning about black hole binaries from their ringdown spectra". In: *Physical Review Letters* 123.16 (2019), p. 161101. DOI: 10.1103/PhysRevLett.123.161101.